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Full Length Research Paper

The effects of different packaging materials on the shelf stability of garri

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The effects of different packaging materials; low density polyethelene (LDPE), high density polyetherlene (HDPE), Hessian bags and plastic buckets on the shelf stability of garri produced from cassava (*Manihot esculenta* Crantz) under tropical ambient temperature was evaluated for 6 months duration. Results indicates that total viable bacteria count increased gradually from 3.0 x 10^1 to 9.9 x 10^3, 1.01 x 10^3, 1.36 x 10^3 and 1.10 x 10^3 cfu/g for LDPE, HDPE, Hessian band and plastic bucket, respectively. Whereas the total viable fungi count increased from no growth to 3.6 x 10^6, 4.1 x 10^4, 3.1 x 10^4, and 1.2 10^7 cfu/g for LDPE, HDPE, Hessian and plastic bucket, respectively. Four fungal genera (*Apsergillus, Penicilium, Fusarium* and *Rhizopus*) and two bacterial genera (*Bacillus* and *Staphylo-coccus*) were detected and isolated. Slight decrease was recorded in the pH with a corresponding slight increase in the titratable acidity (TA) in all the packaging materials. The degree of deterioration in the carbohydrates, protein, lipid, ash and fibre content were in the order of plastic bucket > LDPE > Hessian >HDPE. Overall acceptability scores shows that the various attributes evaluated were significant at various levels amongst the various packaging materials. Findings and data obtained may be useful in developing indices for shelf stability of garri for possible industrialization.

Key words: Packaging materials, shelf stability, garri, tropical temperature.

INTRODUCTION

Garri is the most popular form in which cassava (*Manihot esculenta* Crantz) is consumed by several millions of people in the African continent, especially in the West Africa sub region (Ofuya and Akpoti; 1988; Ogiehor, 2002). The various forms of consumptions as snack (refreshing light meal when soaked in cold water and eaten with coconut, banana, smoked fish or peanut) and as major meal (when made into thick paste called “eba” and eaten with various types of African soups) make it the most popular diet amongst the rich and the poor, with acceptability cutting across the various socio-economic and multi-ethnic groups in Africa (Ogiehor, 2002; Ogiehor and Ikenebomeh, 2004).

Garri production is laborious and cumbersome. Production methods vary from one locality to another resulting in products of non-uniform quality. Post process handling practices such as spreading on the floor, display in open bowls in the market and sales points and the use of various packaging materials to haul finished products from rural to urban areas may exacerbate contamination. Considering the cumbersome nature of production process, the need to have the finished products to cities where large buyers live, the importance of garri in dietary intake and the need to meet the increasing international demand, the evaluation and identification of adequate packaging materials that will keep the overall quality of garri during distribution and at the point of consumption becomes imperative.

This work was designed to evaluate the various effects of various packaging materials on the microbiological, nutritional and organoleptic quality of garri during storage.

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MATERIALS AND METHODS

Source of cassava and garri processing

Cassava root tubers used for this study were obtained from the open markets in Benin City, Nigeria and processed into garri at Supply and Transport Military barrack’s Garri Processing Centre,

Table 1. Total viable bacterial count (cfu/g) of garri during storage in different packaging materials.

Storage period	Fresh (unfried)	Samples (fried)	Packaging materials			
			LDPE	HDPE	Hessian	Plastic bucket
0 h	$3.8x10^6$	$1.0x10^1$	$1.0x10^1$	$1.0x10^1$	$1.0x10^1$	$1.0x10^1$
2 wks			$3.5x10^1$	$1.8x10^1$	$3.1x10^1$	$1.0x10^1$
4 "			$2.8x10^2$	$4.5x10^1$	$1.2x10^2$	$6.4x10^1$
2 mths			$7.2x10^2$	$2.0x10^2$	$3.9x10^2$	$9.8x10^1$
3 "			$1.23x10^3$	$3.3x10^2$	$5.6x10^2$	$3.6x10^2$
4 "			$1.72x10^3$	$6.3x10^2$	$9.6x10^2$	$5.7x10^2$
5 "			$5.8x10^4$	$9.8x10^2$	$1.05x10^3$	$8.9x10^2$
6 "			$9.9x10^4$	$1.01x10^3$	$1.36x10^3$	$1.10x10^3$

Benin City, according to the scheme developed by Adeyemi and Balogh (1985) with slight modifications as previously reported (Ogiehor, 2002).

Packaging

The processed garri was aseptically weighed (5 kg/pack) into low density polythene (LDPE) bags, high density polyethelene (HDPE) bags, Hessian bags and plastic buckets. Prior to packaging, all the packaging materials were sterilized with the aid of industrial ultra violet sterilizer (model UV-2500, Rio, Italy). Thereafter, the various packs were hermatically sealed with a mechanical sealing machine operated manually (Super master, Japan). The packaged samples were kept in the laboratory for at room temperature (30.0±1°C) for six months and were monitored for microbiological, biochemical and organoleptic quality changes.

Microbiological analysis

25 g from each sample were aseptically weighed into 225 ml of 0.1% (w/v) sterilized peptone water in a beaker and allowed to stand for 5 min with occasional stirring with the aid of sterile glass rod. 1 ml portions of different serial decimal dilutions were plated on nutrient agar (Biotech) for total viable bacterial count and potatoes dextrose agar (Biotech) supplemented with chloramphenicol for total viable fungal count. The colonies that developed were enumerated and expressed as colony forming unit per gram (cfu/g) (Harrigan and McCance, 1976). Isolation, characterization and identification of the microorganisms were carried out for qualitative determinations using colonial, morphological and biochemical characteristics (Vanderzannt and Splittstoesser, 1992). The fungal isolates were identified based on examination of the colonial heads, phlalides, conidiophores and presence or absence of foot cells or rhizoids (Samson and Reenen-Hoekstra, 1988; Bounds et al, 1993).

Biochemical analysis

The pH was determined using the method described by Ogiehor and Ikenebomeh (2005), by blending 10 g of each sample in 10 ml sterilized distilled water and using a referenced glass electrode pH meter (Jenway, 3020, England). Titratable acidity (TA) was determined by titrating 0.1 N sodium hydroxide against 10 ml of sample (supernantant of garri soaked in water) using phenolphthalein as indicator (AOAC, 1990). The moisture content, crude protein, lipids, available carbohydrate, ash and fibre content were determined according to the methods described by AOAC (1990). The hydrocyanic acid content was determined by the alkaline titration method (AOAC, 1990).

Sensory quality analysis

The sensory quality was assessed based on parameters such as colour/appearance, aroma/flavour, texture, swelling index and mouldness. Using a nine point hedonic scale, ten member panel who consumes garri on a regular basis was used to score the various quality attributes for overall acceptability (Larmond, 1977).

Data analysis

The various data obtained were subjected to statistical analysis of mean, standard deviation and analysis of variance (ANOVA) and the significant differences of mean determined.

RESULTS

The microbiological, physico-chemical, biochemical and organoleptic changes associated with garri packaged in LDPE, H DPE, Hessian bags and plastic bucket under tropical ambient temperature (30±1°C) are shown in Tables 1 to 3 and Figure 1. Steady but gradual increase was observed and recorded for total viable bacterial and fungal count in all the samples through out the storage period. However, at the end of the storage period, the fungal counts were in the order plastic buckets > LDPE > Hessian bags > HDPE whereas the bacteria count were in the order LDPE>Hessian bags>plastic buckets>HDPE. In addition the fungal counts were higher than the total viable bacteria counts at the end of the storage period in all the packaging materials evaluated. With the exception of LDPE, there was no significant difference in the total viable counts of samples packaged in HDPE, Hessian bags and plastic buckets. Three bactareia (*Bacillus subtilis, Streptococ-cus lactis and Staphylococcus aureus)* and six fungi (*Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Penicillium citrinum, Fusarium moniliforme, and Rhizopus stolonifer)* species were detected and isolated all through the storage period in all the packaging materials investigated (Tables 1 to 3).

Figure 1, shows the various degree of changes recorded in the carbohydrates, protein, lipid, ash, fibre and hydrocyanic acid contents. The degree of deterioration observed was in the order plastic bucket > LDPE > HDPE

Table 2. Total fungal count (cfu/g) of garri during storage in different packaging materials.

Storage period	Fresh (unfried)	Samples (fried)	Packaging materials			
			LDPE	HDPE	Hessian	Plastic bucket
0 h	$1.21x10^5$	ND	ND	ND	ND	ND
2 wks			$0.8x10^1$	ND	$0.3x10^1$	ND
4 wks			$1.1x10^2$	$0.8x10^1$	$0.9x10^1$	$1.8x10^2$
2 months			$3.4x10^2$	$2.0x10^1$	$1.5x10^2$	$4.5x10^2$
3 “			$2.5x10^3$	$1.8x10^2$	$1.2x10^3$	$1.5x10^3$
4 “			$4.4x10^4$	$4.0x10^3$	$2.5x10^6$	$2.0x10^4$
5 “			$1.8x10^6$	$2.5x10^4$	$1.0x10^6$	$2.8x10^6$
6 “			$3.6x10^6$	$4.1x10^6$	$3.1x10^4$	$1.2x10^7$

Each value are the means of duplicate determinations.
LDPE = Low density polyethene.
HDPE = High density polyethene.
ND = Not detected.

Table 3. Changes in the physico-chemical and nutritional quality of garri in different packaging materials at the end of storage period of 6 months packaging materials.

Parameter	Fresh (unfried)	OH fried	Packaging Materials			
			LDPE	HDPE	HESSIAN	PLASTIC BUCKET
pH	3.83±0.01	4.12±0.01	4.04±0.008	4.01±0.00	4.00±0.10	3.89±0.01
TA (%)	0.04±0.00	0.02±0.00	0.03±0.03	0.02±0.00	0.02±0.00	0.03±0.00
MC (%)	43.10±0.14	12.15±0.01	19.18±0.25	14.58±0.03	15.05±0.07	18.05±0.07
CHO (%)	42.45±0.70	71.10±0.28	60.15±0.07	68.50±0.14	65.80±0.42	60.10±0.42
Protein (%)	1.08±0.10	2.59±0.01	1.58±0.11	1.67±0.01	1.80±0.06	0.98±0.03
Lipid (%)	1.97±0.01	0.65±0.02	0.23±0.04	0.49±0.01	0.55±0.01	0.14±0.01
Ash (%)	0.57±0.02	2.00±0.02	0.23±0.04	1.78±0.04	1.55±0.07	0.19±0.02
Fibre (%)	1.08±0.04	2.63±0.01	2.77±0.01	2.66±0.01	2.70±0.01	2.86±0.03
HCN (mg/g)	17.00±0.85	3.71±0.01	2.20±0.14	2.00±0.00	2.12±0.06	2.20±0.00

Each value is the overall mean ± standard deviation for duplicate determinations.
OH = Zero hour.
LDPE = Low density polyethene.
HDPE = High density polyethene.

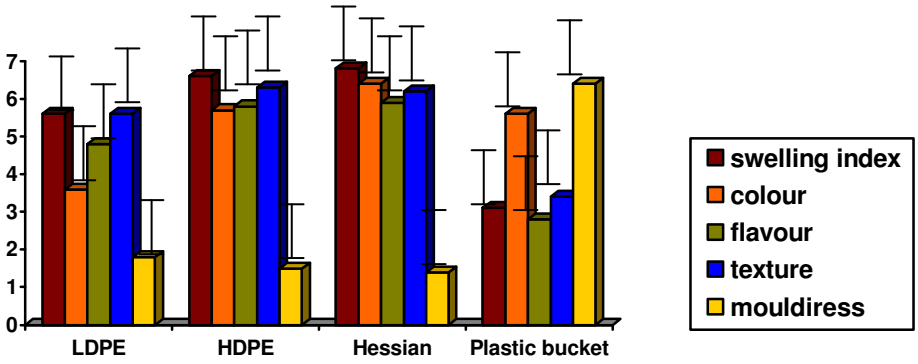

Figure 1. The effects of different packaging materials on the sensory quality of garri at the end of storage period (6 months).

> Hessian bags. While the increase recorded in the moisture content was in the order LDPE > Plastic bucket > Hessian bag > HDPE at the end of the storage period. Slight variation was noticed in the pH which was in the order LDPE>HDPE>Hessian>Plastic bucket while the hydrocyanic acid decreased from 3.71 to 2.20 mg/kg in

LDPE and was fairly stable in all the packaging materials studied.

Changes in the various organoleptic quality attributes such as colour, aroma, texture, and mouldness and overall acceptability score at the end of the storage period are shown in Figure 1. The degree of mouldness was observed to be in the order plastic bucket > LDPE > HDPE=Hessian. The various attributes were significantly different at various levels amongst the different packaging materials while the overall acceptability was in the order Hessian>HDPE>LDPE> plastic bucket.

DISCUSSION

The steady but gradual increase recorded in the total viable bacterial and fungal count in all the samples in the various packaging materials suggests favourable microenvironmental conditions and nutrients availability. However, the variation in the counts observed amongst the various packaging materials may be attributed to their relative permeability to atmosphere gases such as oxygen, carbon dioxide and water vapour. Previous reports (Efiuvwevwere and Uwanogho, 1990; Turtle, 1991; Paine, 1992) show that the oxygen transfer rate (OTR) and the permeability characteristics of the packaging materials evaluated to be in the order, LDPE > Hessian > HDPE>Bucket. However, the high count recorded in samples stored in the plastic bucket may be related to the inability of the permeated gases to escape. Garri being hygroscopic absorb the gases with resultant increase in moisture content which subsequently exacerbate microbial proliferation. Similar reports for other food items have been documented (Steinkraus, 1993; Ogiehor et al., 2004). In addition, the vast array of fungi species detected and isolated compared to bacteria species may be due to the ability of fungi to tolerate and survive in slightly harsh environmental conditions such as low pH and low moisture content. Previous reports support these findings (Adeniyi, 1976; Ekundayo, 1984; Ogiehor, 2002).

The decrease in pH recorded in all the samples in the various packaging materials at the end of the storage period may be related to the activities of the associated microbes which may have increased the release of some organic acids and other metabolites. This may also account for the slight increase recorded in the titratable acidity. Furthermore, similar reasons may be advanced for the various degrees of deterioration or decreases recorded in the carbohydrates, protein, lipid and total ash content of garri in all the packaging materials at the end of the storage period. The decrease recorded among the packages used were found to be in order plastic bucket>LDPE>HDPE>Hessian bags which also coincides with the level of microbial counts recorded. These findings supports previous reports for other food items (Ogiehor et al., 2003; Ogiehor et al., 2004; Ogeihor et al., 2005). The various degrees of changes observed in the quality attributes of colour, flavour/aroma, texture and mouldness amongst the different samples may be partly associated with the migration, permeation, absorption properties of the packaging materials evaluated and partly to the associated microbes, which is similar with previous reports (Linssen and Rooza, 1994; Roa, 1996). However, overall acceptability scores shows that the various attributes evaluated were significantly different at various levels amongst the packaging materials used. Although samples packaged in Hessian were preferred, others were acceptable. These findings suggest that Hessian bags were best at keeping the quality attributes throughout the storage period.

This study has shown that obvious microbiological, physico-chemical, biochemical and organoleptic quality change occurred in garri stored in different packaging materials under tropical ambient conditions. The findings obtained may be useful in the handling and storage of garri.

REFERENCES

Adeyemi O (1976). Fungi associated with deterioration of garri. Nigeria journal of plant protection. 2: 74-77.

Adeyemi M, Balogh B (1985). Processing of indigenous fermented foods. Nig. Food J. 3: 31-34.

AOAC (1990). Official methods of analysis. 11th edition. Association of official analytical chemist Washington DC.

Bounds HC, Boyd FM, Norman JRA (1993). Laboratory exercises in General microbiology. 1st edition. Cambridge University press. pp. 20-26.

Efiuvwevwere BJO, Uwanogho GU (1990). Effects of packaging materials following ethanol and benonyl treatments on chemical and microbiological changes in tomatoe (*Lycophersicon esculentum)* fruits. J.Sci. Food Agric. 52: 393-402.

Ekundayo CA (1984). Microbial spoilage of package garri in storage. Microbial letters 23: 271-278

Harrigan WF, McCance ME (1976). Laboratory methods in food and dairy microbiology. Academic press, London. p. 410.

Larmond EI (1977). Laboratory methods for sensory evaluation of foods. Food research institute Ottawa, Canada Dept. Agric. Pub. 1637.

Linssen JPH, Roozen JP (1994). Food flavour and packaging interaction In: food and preservation. Mathlonti m. (ed). Blackie Academic and professional, London pp. 48-60

Ofuya CO, Akpoti P (1988). Posi processing Microflora and shelf stability of garri. J. Applied Bacteriol. 64: 389-394.

Ogiehor IS (2002). Extension of shelf life of garri by combinations of preservative factors. Ph.D thesis, University of Benin, Benin city, Nigeria. p. 188.

Ogiehor IS, Iyamu MI, Ize-Iyamu KO (2003). Biodeterioration of Akpu produced from cassava (*Manihot esculenta – Crantz*) and the effects of sodium benzoate alone or incombination with ascorbic acids. Advances in Natural and Applied Sciences Research 1: 1-19.

Ogiehor IS, Okwu GI, Enaigbe E (2004). Post fermentation quality changes in bobozi produced from cassava(*Manihot esculenta-Crantz)* and the effects of sodium metabishulphite soaking in combination with refridgeration. Pakistan J. Nutri.

Ogiehor IS, Ikenebomeh MJ (2004). Quality characteristics of market garri destined for consumption in ten selected Nigerian states: Baseline for industrialization Advances in Natural and Applied Sciences Research. 2(1): 17-25.

Ogiehor IS, Ikenebomeh MJ (2005). Extention of shelf life of garri by hygienic handling and sodium benzoate treatment. Afr. J. Biotechnol.. 4(7): 744-748.

Ogiehor IS, Ekundayo AO, Okwu UI (2005). A shelf stability of agidi produced from maize (zea mays) and the effects of sodium benzoate

treatment in combination with low temperature storage. Afr. J. Biotechenol. 4(7): 738-943.
Paine FA (1992). Studies on the safety of water stored in high density polyethevene water bottles. J. Food Technol. 30(4): 256-263.
Samson RA, Reenen-Hoekstra ES Van (1988). Introduction to foodborne fungi, 2nd ed. Central bureau voor schimmel cultures, Boarn.
Steinkraus KH (1983). Handbook of indigenous fermented foods. Microbiology series, vol 9. Mar col Dickkar, New York, p. 273.
Turtle BI (1991). Progress in food packaging despite the odds. Food technology international Europe pp.265-268
Vanderzannt C, Splittstoesser DF(1992). Compendium of methods for the microbiological examination of foods. 3rd ed. American public health association, Washington DC.